LAB. 6

BUFFER SOLUTIONS

Introduction

Buffer: is a solution that resist changes in pH caused by the addition of a strong acid or base. It contain either a weak acid and its conjugate base (the salt of weak acid) or a weak base and its conjugate acid (the salt of the weak base).

Consider a buffer solution that consists of a weak acid and its salt such as the acetate buffer:

$CH_3COOH + H_2O \leftrightarrow H_3O^+ + CH_3COO^-$ (incomplete dissociation)

$CH_3COONa \rightarrow Na^+ + CH_3COO^-$ (complete dissociation)

When a strong base (e.g. NaOH) is added, it will be consumed by the weak acid, forming the conjugate base:

$CH_3COOH + OH^- \rightarrow \mathbf{H_2O} + CH_3COO^-$

When a strong acid (e.g. HCl) is added, it will be consumed by the conjugate base, forming the weak acid:

$CH_3COO^- + H^+ \rightarrow CH_3COOH$

pH measurement: pH values can be measured using:

1. **Mathematical method**: by using the *Handerson-Hasselbalch equation*:
   For a weak acid and its salt:
   $pH = pk_a + \log ([salt]/[acid])$
   For a weak base and its salt:
   $pH = pk_a + \log ([base]/[salt])$
2. **Colorimetric methods**: it is less accurate and less convenient but less expensive than the electrometric method (by using pH meter). Colorimetric methods involves the use of:
   a. *Paper indicator:* A strip of paper that undergo color changes depending on the pH of the solution where the strip is immersed
   b. *Liquid indicators:* They are weak acids or weak bases that show color changes as their degree of dissociation varies with pH. The color of the indicator resembles a certain pH value. An example is *universal liquid indicator*. It consists of a mixture of several indicators (e.g. methyl yellow, methyl red, bromothymol blue, thymol blue, and phenoiphthaline which covers pH range 1-11).
3. **Electrometric method** (by using pH meter).

Buffer capacity (β): is the quantity of strong acid or base that must be added to change the pH of one liter of solution by one pH unit. It is measured in millimoles of acid (or base) per liter of buffer. It represents the ability of a buffer solution to resist pH change. It depends upon the concentration of the buffer.
Buffer capacity can be measured by Van Slyke equation:

$$\beta = \Delta B / \Delta pH$$

Where ΔpH is the change in pH, while ΔB is the small increment of strong base in millimoles.

Materials and equipment

1. 0.2 M Acetic acid, 0.2 M sodium acetate, 0.1 M sodium hydroxide, water, and liquid universal indicator,.
2. Conical flask, volumetric flasks, beaker, pipette, pH meter and paper indicator.

Procedure

1. **Buffer Preparation:** prepare acetate buffer solutions that contain:
   (ml of 0.2 M solution of acetic acid + ml of 0.2 M solution of sodium acetate): (46.3+3.7), (30.5+19.5), (25.5+24.5), (20+30), (14.8+35.2), and (4.8+45.2) respectively.
   Add distilled water to complete the volumes of the buffer solutions to 100 ml.

2. **pH measurement:** the pH of each buffer solution is measured by using each of the following method:

   1) ***Handerson-Hasselbalch equation***: use the equation to predict the pH of the buffer solution (compare this theoretical value with values obtained from experimental measurements). pK_a for acetic acid is 4.76

   2) ***Colorimetric method:***
      a) ***Paper indicator:*** immerse a strip of wide range pH paper into small quantity of buffer solution and observe the color changes of the paper.
      b) ***Liquid universal indicator:*** add 2 drops of universal indicators to 10 ml buffer solution, then compare the color result with color found on the bottle of liquid universal indicator.

   3) ***pH meter:*** Calibrate the pH meter using the pH 7 and 4 buffers provided. Put the electrode of the pH meter in the buffer solution and read the pH.

3. **Buffer capacity calculation:** Add 1 ml portions of 0.1 M of sodium hydroxide to a 25 ml of the acetate buffer solution, measure the pH after each addition until a change of 2 pH unit is achieved, and calculate the buffer capacity.

Group: Subgroup: Date: ***Lab instructor signature:***

Names:

Results

Flask No.	Sol. (A) (mls)	Sol. (B) (mls)	pH				NaOH (mls)	NaOH (mmoles) /25 ml	NaOH (mmoles) /1000 ml	β
			(1)	(2) (a)	(2) (b)	(3)				
1										
2										
3										
4										
5										
6										

Homework:

1. Explain the relationship between buffer capacity and its concentration.
2. Which buffer solution has the highest buffer capacity? Why?
3. If a strong acid (HCl) is added instead of a strong base (NaOH), which buffer solution is expected to have the highest buffer capacity? Why?